Sunlight exfoliated reduced graphene oxide loaded isabgol scaffolds accelerates collagen synthesis, vascularization and wound healing in diabetic rats

Thangavel Ponrasu, PhD, Department of Biotechnology, IIT Madras, Chennai, India 600036.

Lonchin Suguna, PhD, Department of Biochemistry, CSIR-CLRI, Chennai, India 600020.

Vignesh Muthuvijayan, PhD, Department of Biotechnology, IIT Madras, Chennai, India 600036.

Abstract

Statement of the Problem: Diabetes mellitus (DM) is one of the major health concerns with increasing prevalence. Wounds in diabetic patients are slow to heal and persist for few months under proper wound care and management. Pathophysiology of impaired diabetic wound healing is still unclear and it is presumed that delayed healing is due to the persistence of prolonged inflammation and an inadequate angiogenic response. However, an ideal wound dressing materials can act as a protective barrier against pathogens, help in cell attachment, proliferation, migration and differentiation during wound healing process. **Methodology:** Fabrication of the reduced graphene oxide loaded isabgol (Isab) scaffolds (Isab + rGO) was prepared by freeze drying method using sodium tri meta phosphate (STMP) crosslinking. Biocompatibility of the Isab + rGO scaffolds was carried out in NIH 3T3 fibroblast cells. Then, these scaffolds were used as a topical wound dressing material to assess the normal and diabetic wound healing efficacy using 2 × 2 cm^2 full thickness open excision wounds in Wistar rats. Granulation tissue collected from wounds was used to evaluate the biochemical, biophysical, histopathology and immunohistochemistry analyses. **Results:** Isab + rGO scaffolds are biocompatible in NIH 3T3 L1 cells and it also showed significant antibacterial activity. Isab + rGO scaffolds treatment showed increased wound contraction ($p < 0.05$) compared to control and isab scaffold both in normal and diabetic wound healing. Period of epithelialization is also significantly reduced in Isab + rGO scaffolds treated normal and diabetic wounds compared to isab and control. Histopathology and immunohistochemistry results also revealed that the Isab + rGO scaffold dressing accelerated macrophage recruitment and neovascularization to heal the wounds faster. **Conclusion & Significance:** These results demonstrated that incorporation of rGO in isabgol can reduce the prolonged inflammation and enhance the wound healing by accelerating the neovascularization and collagen synthesis. Hence, Isab + rGO scaffold could be an inexpensive wound dressing material for diabetic wound healing application.

Images

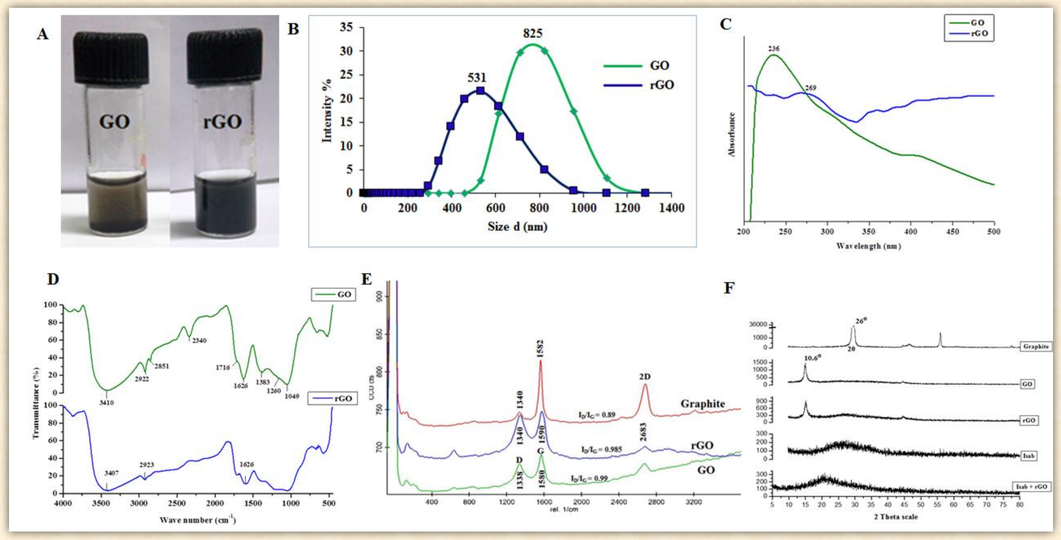

Figure 1: Characterization of GO, rGO and Isab + rGO scaffolds. A). Digital images of dispersed GO and rGO. B). DLS. C). UV-Visible spectra. D). FTIR spectra. E). Raman spectra. F). XRD.

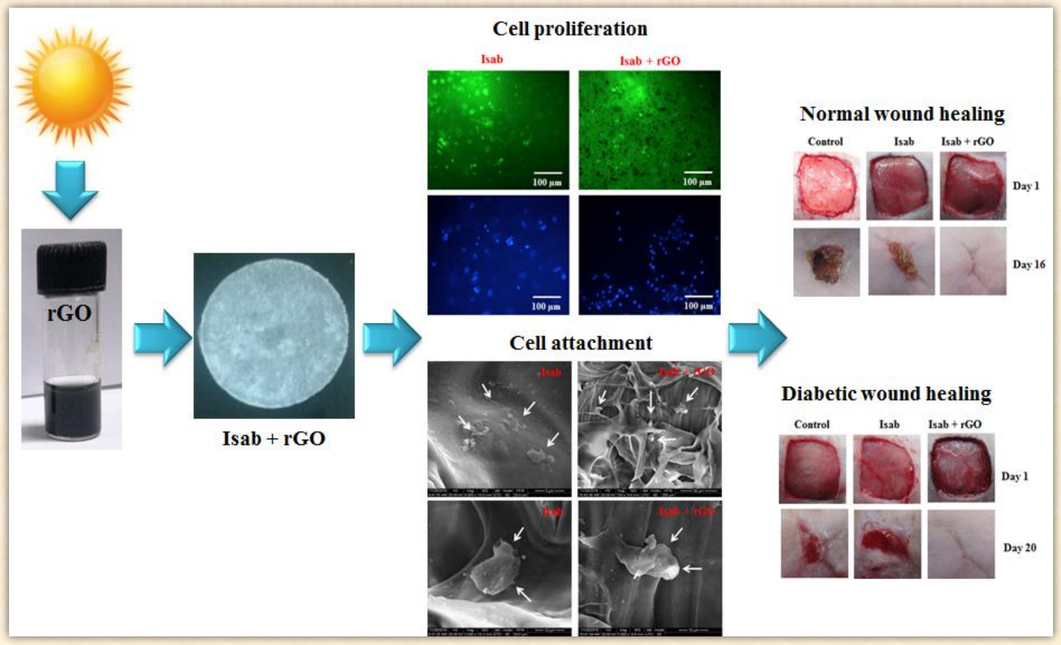

Figure 2: Isab + rGO scaffolds shows biocompatibility in NIH 3T3 fibroblasts and wound healing efficacy in normal and diabetic rats.

Biography

Thangavel Ponrasu has completed his MSc., M. Phil. and Ph.D in Biochemistry. He has skill in fabrication of nanocomposite materials for tissue engineering and diabetic wound healing applications. During his Ph.D, he has gained hands on experience in toxicity evaluation in zebrafish embryos and screening medicinal plants for normal and diabetic wound healing application in Wistar rat model. He has expertise in animal handling and surgical procedure to create full thickness open wounds in rats. Currently, he is pursuing his postdoctoral research in the department of Biotechnology, IIT Madras, India since July 2014. During his postdoc, he is developing novel, inexpensive wound dressing materials to enhance diabetic wound healing. He has published 22 papers in peer reviewed journals so far. He has attended many national, international conferences to present his research findings. He is focusing on the development of inexpensive wound dressing materials to heal the diabetic wounds much faster.

Email: tponrasu@gmail.com

Acknowledgements

First author thanks Indian Institute of Technology Madras for the Institute Postdoctoral Fellowship. Authors acknowledge the Sophisticated Analytical Instrument Facility (SAIF), IITM for characterization of the biomaterial. We acknowledge Dr. Vani Janakiraman and Dr. Purva Bhatter for their help in cell culture work. We also thank Dr. Satish R. Wate, Former Director, CSIR-Central Leather Research Institute for the approval to utilize the animal facility in CLRI.

References

- T. Ponrasu, L. Suguna, Int Wound J. 2012, 9, 613.
- M. Mohandoss, S. S. Gupta, A. Nelleri, T. Pradeep, S. M. Maliyekkal, RSC Adv. 2017, 7, 957.
- V. Eswaraiah, S. S. Jyothirmayee Aravind, S. Ramaprabhu, J. Mater. Chem. 2011, 21, 6800.
- S. Mukherjee, P. Sriram, A. K. Barui, S. K. Nethi, V. Veeriah, S. Chatterjee, K. I. Suresh, C. R. Patra, Adv Healthc Mater. 2015, 4, 1722.
- S. R. Shin, C. Zihlmann, M. Akbari, P. Assawes, L. Cheung, K. Zhang, V. Manoharan, Y. S. Zhang, M. Yüksekkaya, K.-t. Wan, M. Nikkhah, M. R. Dokmeci, X. Tang, A. Khademhosseini, Small 2016, 12, 3677.